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The Challenge of Measuring Odour's Impact

Research and new technology will provide new options for measuring and controlling odour.

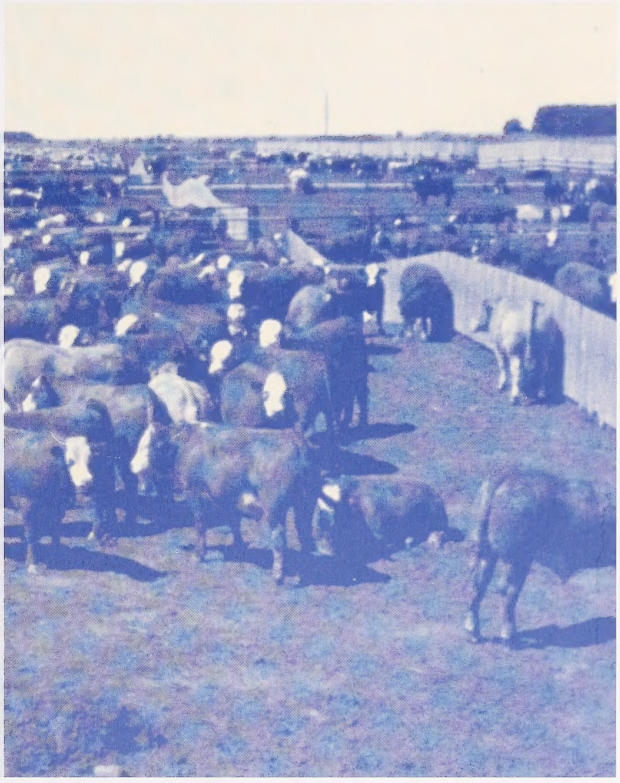
Nuisance and health concerns caused by odours from livestock facilities are one of the key issues affecting the growth of the livestock industry in Alberta.

A number of factors determine whether odour is a nuisance, including the human sense of smell and people's psychological and physiological make-up. As well, a changing rural population, and the trend to large-scale agricultural production, also have an effect.

"Research and technology development are going to play an increasingly important role in determining odour nuisance levels and in the development of odour control measures," says Sherry Perih, an Agricultural Engineer-in-Training with Alberta Agriculture, Food and Rural Development (AAFRD), who has worked on livestock odour issues.

"While odour control technology is advancing, the inability to accurately evaluate the performance of odour-mitigating technologies can have serious economic impact on the livestock industry," says Perih. "Also, in the absence of a clear understanding of laboratory and field odour measurement techniques, it is difficult to evaluate the true socio-environmental effects of odour. It is essential, for example, that the methodology used to establish setback distances be consistent and fair."

A new approach in Alberta is the Odour Control Team, a group of AAFRD, University of Alberta and Alberta Research Council engineers and scientists. The team's mission is to use science-based, engineering approaches to address the issue of livestock odour. The researchers will share resources and collectively analyze and develop new tools for measuring and controlling odour.



"Livestock odours are complex. They are made up of numerous compounds and vary with each type of livestock," says Perih. "Understanding odour, measuring it and controlling it takes a multifaceted approach, which is why the Odour Control Team, consisting of researchers with various expertise, was formed."

This issue of *AgTech Innovator* is the first of a two-part series on odour. It examines what odour is, the challenges of measuring it, how it's measured now, as well as new approaches for tackling the issue of odour. The second part of this series will examine odour control technologies.

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Understanding odour and human sense of smell

Odour is complex and so is the human reaction to it.

All odour results from a blend of substances and their interactions.

"Over 165 volatile compounds have been reported in odour from swine production," says Perih, an Agricultural Engineer-in-Training. "Most of the odorous substances can be grouped into different classes of chemical compounds, such as volatile fatty acids, phenols, nitrogen derivatives and reduced sulphur compounds. The chemical compounds stem from the degradation of plant fibre and protein as well as the anaerobic degradation of more complex compounds."

This complexity at the source is matched by the complexity in human reaction to odour.

Human sense of smell

The human sense of smell is a primary factor in the human sensation of comfort. "Research shows that smell perception is unique to each individual and varies over time because of changes to the physical condition of the individual and the individual's memory of exposures to similar odours," says Perih.

Smell reaction from an individual is the result of the stimulus created by the olfactory bulb, located at the top of the nasal cavity, coming in contact with odorous molecules. Signals are sent to the olfactory centre in the brain through five nerve fibres. The odour impression is created and compared with the person's odour "memory," based on individual perceptions and social background.

Psychological response to odours is more complex and less understood than the physiological response. "Evidence suggests that each of us learn to like or dislike certain odours," says Perih. "Children like most smells, but it is only as we mature and begin to talk about odours that we develop a sense of which smells we like and dislike.

"This is one reason why reaction to odour emissions from livestock production may appear subjective and can vary from one community to another," she says. "There are examples from rural communities where people have complained about odour emanating from a hog facility when it was actually empty."

The human nose reacts to the odorous mix and not to a single compound in that mix, says Perih. Research is attempting to relate odour measurement to specific chemical components, such as ammonia, hydrogen sulphide and fatty acids.

FIDO analysis

"Research linking chemical levels to odour levels is developing, but it is difficult to relate a specific chemical concentration to odour levels," she says. "Extreme variability of sources, environmental factors and human responses make it difficult to measure odour intensity or determine an acceptable limit for livestock odours."

The response to odours does not always correspond to its intensity or odour concentration. Therefore odour nuisance is generally defined by the FIDO factors: frequency, intensity, duration and offensiveness.

- **Frequency.** How often an odour occurs.
- **Intensity.** The strength of an odour.
- **Duration.** The length of time the odour is encountered.
- **Offensiveness.** The unpleasantness or character of the odour.

These four factors contribute to determining whether a given odour may or may not be a nuisance problem. "Although, it is odour intensity that has received the most attention as an indicator in measuring the presence of odours," she adds.

Odour-measuring technology

Since odour intensity is considered one of the primary variables in determining odour problems, a variety of methods for measuring odour intensity have been developed. "To date, a human sniffing panel is the most reliable method of odour evaluation," says Sherry Perih, an Agricultural Engineer-in-Training.

Olfactometer. Odour samples, collected in special sampling bags, are taken to an olfactometry lab. In the lab, trained odour panellists, typically eight, smell samples from three sniffing ports. One of these ports contains the diluted odour sample, while the other two are non-odourous samples.

Each panellist declares his reaction to the odour sample as a "guess," "detection" or "recognition." Panellists then receive another set of three samples to smell. However, this next set presents the odour at a higher concentration (i.e., two to three times). This continues until there is recognition of the sample by the panellists. This results in an overall declaration that the sample contained x number of odour units, which is odour concentration.

Both the U of A in Edmonton and ARC in Vegreville have olfactometry labs.

Establishing a Science-Based Approach to Odour Measurement

Major research effort focuses on objectively identifying fair separation distances between confined feeding operations and neighbouring residences, communities and land uses.

Alberta's Odour Control Team, a group of researchers from the University of Alberta, Alberta Research Council and Alberta Agriculture Food and Rural Development, is using a multi-pronged research strategy to scientifically define odour levels and establish clear, objective guidelines for Minimum Distance Separation (MDS) in Alberta.

"Currently, the human nose is the best instrument for measuring odour," says team member Sherry Perih, an Agricultural Engineer-in-Training with Alberta Agriculture, Food and Rural Development. "Measurements may be conducted in the laboratory using an olfactometer (panel of certified evaluators) or in the field with trained odour 'sniffers.'"

Now researchers want to build on that experience and knowledge by developing a science-based siting tool for confined feeding operations (CFOs) and odour monitoring procedures to increase confidence in the licensing, siting and odour monitoring of CFOs in Alberta, she says. The project will:

- Develop standardized laboratory protocols and procedures to minimize variations and increase the statistical level of confidence in odour measurements.
- Scientifically measure odour emission rates (OER) used to develop a database for various CFOs.
- Calibrate air dispersion models to predict odour in the vicinity of CFOs using field data collected by trained odour "sniffers."
- Scientifically determine acceptable odour exposure levels at places of human residence or activity in proximity to CFOs.
- Quantify the MDS category factors in the new CFO regulations and develop a scientific tool for siting CFOs. This complements experience-based MDS.
- Identify new and existing odour measurement techniques that are cost effective.

"This science-based approach will be used to complement the current experience-based MDS, says Perih. "On the environmental side, proven scientific understanding of odour from livestock facilities, its impacts, and its socially acceptable levels, will add to existing siting tools that minimize negative impacts of odour."

On a societal level, producers and the general public will gain confidence in the regulation of livestock operations. "This increased confidence will arise from reliable scientific data supporting odour-related policies that guide the expansion of existing livestock operations and the siting of new operations."

Producers also stand to benefit, she says. "Increased confidence related to the potential odour impact of livestock operations will allow for easier expansion and development of the livestock industry. This project will ensure accurate assessment of odour control technologies, giving livestock producers the ability to make well-informed technological and economic decisions regarding odour control technologies."

Nasal Rangers and Odour School. Odour School is a training course conducted by St. Croix Sensory Inc., Stillwater, Minnesota. Nasal Rangers are used to measure odour intensity. This course prepares trainees in the field evaluation of ambient odours. The purpose of the training is to produce a qualified observer whose judgement of odours will be consistent and minimally affected by variable field conditions.

In May 2001, approximately 45 people from Alberta, Saskatchewan and Manitoba attended an Odour School. At the end of the program, the participants were awarded Nasal Ranger certificates.

The Nasal Rangers who participated in this study were calibrated relative to the five-point odour intensity referencing scale – the range of intensities presented by a five-point scale that represents the range of intensities of pig odour downwind from a pig production site.

Electronic nose The electronic nose is a developing technology. Scientists studying the mechanism of how the smell process works in humans are trying to use electronics to mimic the processes involved. Sensor arrays emulate the different type of olfactory sensors found in the human nose. The sensor response results in specific patterns. These patterns are then compared to the responses of known sample standards to characterize the odour.

The science-based approach will also provide regulators with the ability to make proper adjustments to the MDS based on proven odour-mitigating technologies proposed by producers, she says.

Air dispersion

One of the keys to this science-based approach is the *Calibration of an Air Dispersion Model for Alberta Conditions* study, says Perih, one of the leaders on this project.

"This study is the first step in calibrating standard air dispersion models to fit Alberta conditions for odours emitted from livestock facilities," she says. "Some of the challenges inherent in this study are the variable, transient natures of agricultural odours and the high costs of carrying out conventional olfactory measurements."

Steps in the research project so far include: calibration of olfactometry-based odour measurements to field measurements from trained observers; development of of a field protocol to measure odour plumes; construction of a wind tunnel to measure surface emissions from storages; and collection of field data.

Work is currently underway to calibrate the model based on information collected. In 2001, two swine barns were selected in central Alberta. A field protocol was developed and trained observers (Nasal Rangers) from the U of A and AAFRD measured the odour dispersion for four weeks at each site at 6 a.m., noon and 6 p.m. For each test, five observers were positioned 950 metres downwind from the barn, spread across a 22.5 degree arc, and were moved 150 metres closer the barn every eight minutes.

Barn odour emissions were measured by olfactometry. Manure storages were measured using a wind tunnel, based on an Australian model, constructed by the AgTech Centre.

"This project will provide us with the background information and experience to underpin the Odour Team's objective of upgrading siting tools and MDS standards for Alberta."

Odour Control Team

The air dispersion study is one of the long-term goals of the Odour Control Team. The team's three-year goals are to: be able to measure odour with confidence; define acceptable community odour standards; develop a science-based siting tool; provide a selection of odour control tools to producers and communities that will be promoted through technology transfer and extension; create an effective communications network that has credibility with the public and the agriculture community.

"Our first priority is to develop odour sampling and measuring procedures," says Sherry Perih. "We want to ensure the accuracy of the technology and techniques we use to measure odour."

Defining community acceptability criteria for frequency, intensity, duration and offensiveness of livestock odour is also key. "One of the objectives here is to develop a siting tool that predicts the influence of odours from new and existing livestock operations on communities," she says. "An odour database is also in the works, which will include source information, odour concentrations, emission rates, etc."

Helping producers to control odour is also vital. A prime objective is the development of an odour management planning tool that evaluates odour control technology, design criteria, cost/benefits and management/monitoring requirements, she says. "We want to look at both in-barn and out-barn odour control and evaluate various odour control technologies, including biolfilters, oil sprinkling, manure additives, nutrition, manure application, etc."

Communication is critical in the Odour Team's efforts. "We want to establish a network and strategy with technology developers and researchers," says Perih. "As well, we will compile and disseminate appropriate and accurate odour information for Alberta conditions and the agricultural industry."

A major initiative of the Odour Control Team is to produce an Odour Control Manual based on the current literature and findings from the team's research. The manual will include general information about odour and odour control options, complete with cost, design criteria, odour control efficiency information and worksheets to guide producers through an odour assessment of their farm and help them develop an odour control plan.

By helping the industry minimize livestock production odour, the team will help the livestock industry co-exist respectfully with rural and urban communities.

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